**The History of the Gamma Knife by** Jeremy C. Ganz

No invention or discovery is ever produced in a vacuum. Firstly there must be a perceived unfulfilled need. From need to concept to fruition in the form of a useable new method is painstaking and time consuming. This part of the process may involve useful but sub-optimal new ideas or methods which require repeated adaptation. Chance also plays a part. Moreover, a treatment perceived imperfectly initially, may be improved by totally different persons from those who first initiated the new notions and the honour may well go to the discoverer of the successful adapted method rather than to the original creative thinker who initiated the investigations which ended in success.

In 1951 Leksell wrote a seminal paper on radiosurgery which was a statement of concepts all of which were remarkably well understood. The first cases treated with an available industrial X ray machine attached to the Leksell arc and frame were successful enough to stimulate further efforts to improve the method.

Later, Leksell and the physicist Börje Larsson performed radiobiology experiments carried out on rabbits and goats to determine and quantify the effects of focused fine beam radiation on brain. The aim was destroy normal brain with a view to treating functional disease in the brain using focused radiation. There was dissatisfaction with proton radiosurgery and it became accepted in Sweden that proton beam radiosurgery was too complex and impractical. A new machine was needed. It would have a static design. Complex collimators were designed which using sources of $^{60}$Co could produce beams with acceptable characteristics. The geometry of the machine was determined including the distance of the sources from the patient and the optimal distance between the sources. The first Gamma Unit was built with private money and with no contribution from the Swedish state, which nonetheless required detailed design information in order to ensure radiation safety. This original machine was built with rectangular collimators to produce lesions for thalamotomy for functional work. However, with the introduction of dopamine analogues this indication virtually disappeared over night.

The inventors were very excited and drove the first patient from Stockholm over 100 km for the first treatment in Studsvik. The treatment was a technical success. The new machine was transported to Sophiahemmet (a private Stockholm hospital) and installed. A further 8 patients were treated and assessed. For 14 years Stockholm was the only location where a Gamma Unit was in use. During this period a variety of indications were treated. A new Gamma Unit was made this time with round collimators more suited to the task in hand. All in all 762 patients were treated during this time with 209 vascular, 342 tumor and 177 functional indications. There were also 34 miscellaneous cases. All these cases were treated before the introduction of computerized imaging.

Leksell's conservatism led him to underestimate the demand for new Gamma Units. When two of his students wanted machines in respectively Buenos Aires and Sheffield, there was no possibility for manufacture in Sweden. Arrangements were made for a Swiss company to make two machines which were installed in the two centers but not without problems. Eventually, since the demand was there, arrangements were made to continue manufacture in Sweden by Elekta, the company which still makes them today. When these matters were settled, the first USA model was installed in Pittsburgh. This became a crucial development, partly because the machine was now established in the United States, but also because of the quality of the publishing from Pittsburgh which was of the highest quality, honest and believable and thus a potent impulse in the spread of Gamma Knife treatment.

Following growing acceptance of Gamma Knife radiosurgery there were a number of debates about the treatment of various indications. The indications affected included AVMs, meningiomas, pituitary adenomas and vestibular schwannomas. Metastases were not treated in Stockholm because of Leksell's opposition to the treatment of malignant disease and indeed these tumors became a generally popular indication rather later.

The term Gamma Knife was first used later by the Pittsburgh group. In the earliest days there was no computerized dose planning system. However, it was not long before the first dose planning system KULA was developed in the mid-1980s. It soon became apparent that while this was geometrically accurate, it was not as visually attractive as programs used by other technologies. It had been designed in the era prior to computerized imaging and had only limited capacity for dosimetry. It was followed by GammaPlan which has evolved over the years into a sophisticated multiparameter system with advanced graphic features.

The Gamma Knife continued to evolve. The first machines used helmets containing collimators of different diameters increase the flexibility of the treatment. Changing these helmets was time consuming and tedious. The original model and that introduced into the USA was the U model where the patient was inserted into the machine inwards and upwards, using hydraulics. A new simpler machine was devised called the B model where the patient simply moved in and out, but there was still the problem of changing helmets. Then the C model was introduced, with a robot called the automatic positioning system (APS) which permitted the patients position to be moved automatically. However, the helmets still had to be changed when collimators of different sizes were required. Finally, an entirely redesigned model called Perfexion was introduced where there were no helmets and the patient once placed in the machine would be treated completely following a single pressure on a button.
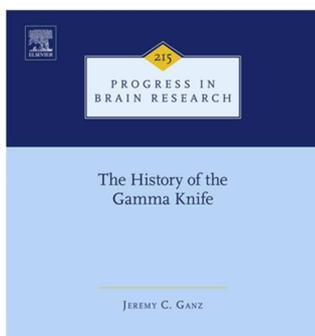


The history of the Gamma Knife, by Jeremy C. Ganz has recently been published by Elsevier.